

**CLAIMS:**

1. A method of making a thin film layered superlattice material on an integrated circuit substrate using trimethylbismuth, said method comprising the steps of:

5 dissolving said trimethylbismuth and a metal compound in a solvent to produce a final precursor liquid;

forming a mist of said final precursor liquid with a carrier gas to produce a precursor mist;

vaporizing said precursor mist to produce a precursor vapor;

10 providing said integrated circuit substrate;

applying said precursor vapor onto said substrate to produce said thin film superlattice material without any heating step that includes a temperature of 650°C or higher; and

completing the fabrication of said integrated circuit to include at least a portion of said thin film layered superlattice material in a component of said integrated circuit.

2. A method as in claim 1 wherein said step of dissolving said trimethylbismuth comprises mixing said trimethylbismuth with an organic solvent.

3. A method as in claim 1 wherein said metal compound comprises a metal polyalkoxide compound containing at least two metals selected from the group consisting of strontium, calcium, barium, cadmium, lead, tantalum, hafnium, tungsten, niobium, zirconium, bismuth, scandium, yttrium, lanthanum, antimony, chromium, molybdenum, vanadium, ruthenium and thallium.

25 4. A method as in claim 1 wherein said metal compound comprises a diketonate compound containing at least two metals selected from the group consisting of strontium, calcium, barium, cadmium, lead, tantalum, hafnium, tungsten, niobium, zirconium, scandium, yttrium, lanthanum, antimony, chromium, molybdenum, vanadium, ruthenium and thallium.

30 5. A method as in claim 1 wherein said metal compound comprises an oxide compound containing at least two metals selected from the group consisting of strontium, calcium, barium, cadmium, lead, tantalum, hafnium, tungsten, niobium, zirconium, scandium, yttrium, lanthanum, antimony, chromium, molybdenum,

vanadium, ruthenium and thallium.

6. A method as in claim 1 in which the amount of trimethylbismuth is less than 15 mol%.

7. A method as in claim 1 in which the amount of trimethylbismuth is less  
5 mol%.

8. A method as in claim 1 in which the amount of trimethylbismuth is 8  
mol%.

9. A method as in claim 2 wherein said organic solvent comprises at least  
one compound selected from the group consisting of tetrahydrofuran, methyl ethyl  
10 ketone, isopropanol, methanol, xylene, n-butyl acetate, octane, 2-methoxyethanol,  
toluene, diethylethane, 1,4-dioxane and hexane.

10. A method as in claim 1 wherein said step of forming a mist of said  
precursor liquid comprises flowing said carrier gas across an open throat of a tube  
containing said precursor liquid, with the flow of said gas being substantially parallel  
to said open throat.

11. A method as in claim 1 and further including a step of flowing oxygen  
gas into said deposition chamber reactor prior to said step of reacting.

12. A method as in claim 1 and further comprising at least one step of  
treating said thin film at temperatures below 650°C to crystallize or partially crystallize  
said superlattice material in a phase including more grains with a high polarizability  
orientation than prior to said at least one step of treating, whereby said at least one  
step of treating is RTP, oxygen furnace annealing prior to formation of an electrode  
or contact to said layered superlattice material thin film, or an anneal after an  
electrode or other contact to the superlattice material thin film is formed.

25 13. A method as in claim 1 wherein said step of mixing said precursor mist  
comprises mixing said precursor mist with an inert carrier gas.

14. A method as in claim 1 wherein said carrier gas comprises at least one  
compound selected from the group consisting of nitrogen and argon.

30 15. A method as in claim 1 wherein said step of vaporizing comprises  
heating said precursor aerosol prior to said deposition step.

16. A method as in claim 15 wherein said step of heating further comprises

heating said precursor aerosol to a temperature of from 50°C to 250°C.

17. A method as in claim 15 wherein said step of heating further comprises heating said precursor aerosol to a temperature of from 100°C to 200°C.

18. A method as in claim 1 wherein said step of providing said substrate  
5 further comprises placing said substrate inside a deposition chamber.

19. A method as in claim 18 wherein said step of applying said precursor vapor comprises chemical vapor deposition.

20. A method as in claim 1 wherein said step of applying said precursor vapor further comprises deposition on a heated substrate.

10 21. A method as in claim 1 wherein said step of applying said precursor vapor further comprises deposition on an ambient temperature substrate.

22. A method as in claim 1 wherein the thin film layered superlattice material is 1nm to 100nm thick.

15 23. A method of making a thin film layered superlattice material on an integrated circuit substrate using trimethylbismuth, said method comprising the steps of:

dissolving said trimethylbismuth and a metal compound in a solvent to produce a precursor liquid, with the relative concentration of said trimethylbismuth to said solvent being 15 mol% or less;

20 forming a mist of said precursor liquid with a carrier gas to produce a precursor mist;

vaporizing said precursor mist to produce a precursor vapor;

providing said integrated circuit substrate;

25 applying said precursor vapor onto said substrate to produce said thin film superlattice material without any heating step that includes a temperature of 650°C or higher; and

completing the fabrication of said integrated circuit to include at least a portion of said thin film layered superlattice material in a component of said integrated circuit.

24. A precursor solution for forming a layered superlattice material, said precursor comprising trimethylbismuth and a metal compound in a solvent, with the relative concentration of said trimethylbismuth to said solvent being 15 mol% or less.

25. A precursor solution as in claim 24 wherein said metal compound comprises a metal polyalkoxide compound containing at least two metals selected from the group consisting of strontium, calcium, barium, cadmium, lead, tantalum, hafnium, tungsten, niobium, zirconium, bismuth, scandium, yttrium, lanthanum, 5 antimony, chromium, molybdenum, vanadium, ruthenium and thallium.

26. A precursor solution as in claim 24 wherein said metal compound comprises a diketonate compound containing at least two metals selected from the group consisting of strontium; calcium, barium, cadmium, lead, tantalum, hafnium, tungsten, niobium, zirconium, scandium, yttrium, lanthanum, antimony, chromium, 10 molybdenum, vanadium, ruthenium and thallium.

27. A precursor solution as in claim 24 wherein said metal compound comprises an oxide compound containing at least two metals selected from the group consisting of strontium, calcium, barium, cadmium, lead, tantalum, hafnium, tungsten, niobium, zirconium, scandium, yttrium, lanthanum, antimony, chromium, molybdenum, vanadium, ruthenium and thallium.

28. A precursor solution as in claim 24 in which the amount of trimethylbismuth is 10 mol% or less.

29. A precursor solution as in claim 24 in which the amount of trimethylbismuth is 8 mol%.

30. A precursor solution as in claim 24 wherein said solvent comprises at least one compound selected from the group consisting of tetrahydrofuran, methyl ethyl ketone, isopropanol, methanol, xylene, n-butyl acetate, octane, 2-methoxyethanol, toluene, diethylethane, 1,4-dioxane and hexane.